Persistent Monitoring Platforms

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We plan to build and test a model of the power plant for a stratospheric aircraft powered by thermal energy from the sun. Such an aircraft could maintain station over a designated ground location almost indefinitely, since it would not need fuel. We are developing a thermally-coupled system with an efficiency nearly an order of magnitude better than the state of the art (Helios), by creating the technology for a sun-tracking solar-heat collector, a thermal-storage reservoir, and a high-efficiency heat engine.

Project Goals

We will develop and validate the physics models to prove the principles involved in a solar thermal-powered aircraft, in preparation for constructing a prototype scale-model aircraft to demonstrate station-keeping capability at sea level. Successful demonstration of this technology would set the stage for construction of a stratospheric-altitude prototype capable of circumnavigating the globe.

We will also develop physics models for thermal transport, materials interactions, loss mechanisms, and engine performance in the stratosphere's environment.

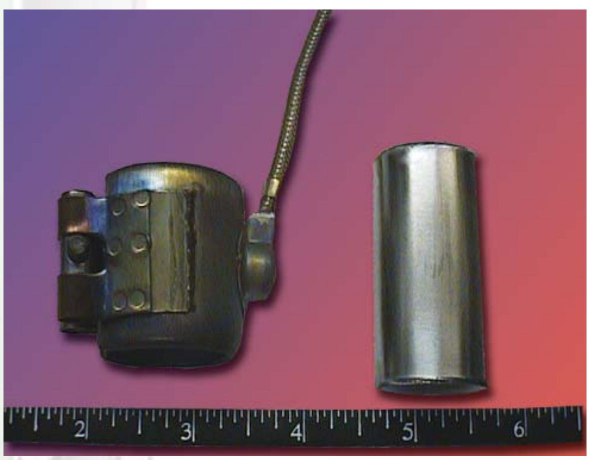

Figure 1. LiH experimental test capsule and heating unit.

Figure 2. LLNL's Jim Emig loading LiH into test capsule.

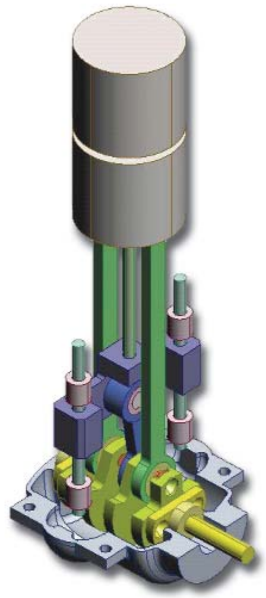

Figure 3. Conceptual design of our Stirling engine. Features include a power piston/cylinder wall, a displacer piston/cylinder wall, and crankcase feed-through journal bearing. There is virtually no limit to the operating altitude for the engine.

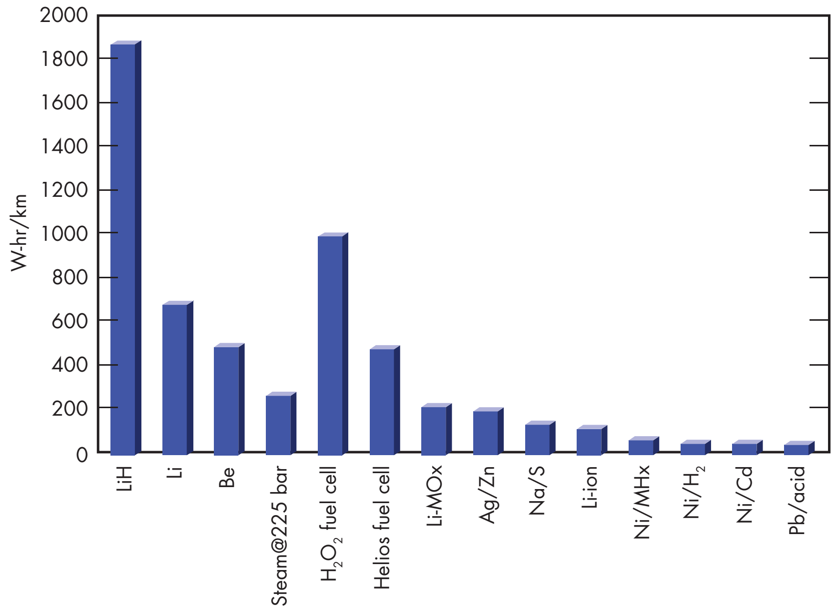

Figure 4. Chart showing LiH thermal energy compared to rechargeable batteries.

Relevance to LLNL Mission

Persistent surveillance, having essentially unlimited dwell-time over a region of interest, would enable the acquisition of a qualitatively new type of intelligence information for various national-security applications, such as countering the proliferation of weapons of mass destruction. Furthermore, inexpensive persistent surveillance has direct utility in border monitoring for homeland-security missions.

FY2004 Accomplishments and Results

We constructed a lithium hydride (LiH) thermal battery core, and developed a layered containment structure that can safely contain high-temperature, reactive LiH in equilibrium with a significant pressure of hydrogen gas (see Figs. 1 through 3). A thermal battery based on LiH has more than an order of magnitude higher specific energy capacity than the most advanced rechargeable electric batteries (see Fig. 4). We developed a comprehensive suite of physics models for each of the components in the thermal powered aircraft. The modeling study culminated in the submission of a patent application broadly covering the multiple aspects of a high-efficiency solar-powered aircraft.

FY2005 Proposed Work

For FY2005, we have two primary goals. One goal is to develop a heat engine whose thermal efficiency is at least 60% of the Carnot limit. To this end, we plan to closely couple computational fluid-dynamics models with experiments on a prototype Stirling engine. The second primary goal is to conduct laboratory experiments on the LiH thermal battery invention developed in the first year. We will use nondestructive evaluation techniques to monitor, in real time, the cooling characteristics of the thermal battery as it discharges, and compare the experimental observations with theoretical predictions.